Forecast Models

Strengths and weaknesses
of
NOGAPS, ADVCLD, AVN, MRF, MM5

NOGAPS

This model (Version 3.4) is the primary spectral model used by AFWA. It has 18 vertical levels and an effective horizontal resolution of approximately 1.5° of latitude and longitude. The model includes effects of atmospheric radiation with a diurnal cycle, clouds, and large-scale precipitation. NOGAPS makes 5-day forecasts of the atmosphere, surface to 10 mb, twice daily from data gathered at 0000Z and 1200Z. NOGAPS has the highest skill in the Atlantic Basin and the least skill in the Tropics. The skill at the 500 mb level is better than National Center for Environmental Prediction (NCEP) spectral models.

Tendencies/Weaknesses

- Surface lows are slow to deepen and move during the early stages of development, as well as slow to fill after reaching minimal pressure.
- Surface lows north of the polar front jet (PFJ) are generally forecast too deep. These are usually mature lows which have bottomed-out and tend to be slow to fill. Surface lows south of the polar jet are forecast too weak and slow.
- NOGAPS tends to merge complex lows into one, usually deeper low pressure system, especially at the extended forecast times.
- Surface lows associated with the formation of upper-level cut-off lows in the cool season are minimally overforecast (deep). Mature cut-off lows are slow to fill after bottoming-out. Occasionally, NOGAPS tends to overforecast the deepening rate of surface cut-off low at the extended forecast periods.

- Moisture is overforecast over land.
- Explosive cyclogenesis (deepening rate 15 mb or greater in 24 hours) is slow to deepen, and central pressures are underestimated on analysis.
- Surface highs are often 1 mb to 2 mb too high.
- NOGAPS tends to overforecast tropical cyclone (TC) genesis frequency and intensification. In the development stage, forecast TCs are slow to move. After reaching maximum intensity, mature tropical cyclones continue to be slow to move during and after transition to extratropical.

- Himalayas, and Antarctica are unreliable because NOGAPS does not directly analyze SLP over high terrain--it analyzes terrain pressure. In the warm seasons, late Spring Sea-level pressure analyses and forecasts over the very high terrain of Greenland, to early Fall, a spuriously deep surface low is observed in the analysis and forecasts over the very high terrain of the Himalayas (vicinity 30° N - 90° E). This "lock-in" feature is caused by model reduction of station pressure to sea level, and the warm season surface air temperatures.

- Upper-level heights are too low north of the polar jet and too high south of the polar jet.

- Surface temperatures tend to be too cool over land. Temperatures in the mid-troposphere and lower stratosphere are slightly cool, whereas temperatures in the upper stratosphere are slightly warm.

- Upper-level short wave troughs in strong zonal and broad meridional flow are minimally weak. The associated developing surface low tends to be slow to deepen and 3 to 4 mb weak.

- The formation of upper-level cut-off lows continues to be well forecast in the transition seasons. The associated surface low is minimally overforecast and deep throughout.

- NOGAPS wind speed forecast variability is greatest in the 300 to 250 mb jetstream region of the upper troposphere with a mean error of 10 kts by 48 hrs.

Region Specific NOGAPS Tendencies

- Asia deepening land lows over Manchuria tend to be overforecast and 3 to 4 mb too deep by 36 to 48 hrs. Asia mature land lows are 3 to 4 mb too deep and slow to fill after bottoming-out.

- Oceanic Areas- Due to the general tendency to underforecast oceanic developing, deepening surface lows and overforecast oceanic mature, filling surface lows; NOGAPS surface wind speed forecasts associated with these lows also exhibit similar biases.

- Meridional flow: deepening lows are minimally ahead of the analysis track (fast to move), especially at the extended forecast period; filling lows are typically biased to the left of the analysis track (toward the upper-level cold air).

- Strong zonal flow or broad flow: deepening lows are ahead of the analysis track (fast to move), especially at the extended forecast period; mature lows are usually biased behind the analysis track (slow to move), and right of the analysis track at extended forecast period.

- Western Pacific tropical cyclones are slow to move during and after transition to extratropical.
- During the primary North Pacific TC season (June through November) TC development tends to be overforecast in the size of the circulation in the northwest North Pacific. In the eastern North Pacific off the West Coast of Mexico, there is a significant overforecast tendency as related to the number of TC systems. Nevertheless, the overforecast tendency does provide early identification of potential TCs.

Aviation Run Model (AVN)

The Aviation Model (AVN) is one of the oldest operational models used by forecasters today. The AVN model was developed primarily to aid in forecasting for aviation. The AVN gives short range forecasts like the NGM and ETA models do, but it also forecasts well into the medium range with forecasts up to 120 hours into the future. The resolution of the AVN model is about 105 km, which is not as good as the NGM or ETA models, but it still provides valuable insight into the future state of the atmosphere. The AVN also tends to perform better than the other models in certain weather situations, such as a strong low pressure area near the East Coast of the US. The AVN also has its own set of statistical equations that use the AVN model output. The AVN is run twice a day (00Z and 12Z databases) for field use and twice a day for in-house evaluation/verification (18Z and 06Z databases). The advantages of the off-time (18Z and 06Z) AVN runs are increases of 2 to 3 hours in the daily mean skill of all AVN forecast products and improvement in supporting other NCEP forecasting activities, i.e., mesoscale and hurricane models. Since the AVN and MRF are derived from the same global spectral model and the only difference is in the data cut off times, the AVN will generally display the same biases as the MRF.

Strengths

- Generally the AVN may be the first short-range model to forecast cyclogenesis when it is possible. But it can be too slow with the deepening rates of surface cyclones. The AVN does the best with filling cyclones.
- The AVN has the smallest errors of any models on position of surface lows. It is best at simulating filling lows, but too slow with deepening ones.
- The AVN is superior to the NGM and ETA Model in forecasting the position of surface lows.
- The AVN tends to have the smallest position errors for cyclones and anticyclones at days 2 and 3.

Weaknesses

- Generally, AVN temperatures are too cold, mainly across the eastern US.
- Generally, the AVN has a tendency to be too far north and west with surface cyclones forming in the lee of the Rockies. This is especially true when the mid/upper trough is still digging into the the Great Basin
- Often the AVN will overdevelop a lead short-wave trough and allow its unrealistically deep surface response to advance too far north and west. Once the mid/upper trough and/or closed cyclone center has advanced to the lee of the Rockies, the surface cyclone placement is fairly reasonable.
- The AVN often underdevelops surface lows, especially over the oceans.

- The AVN has a tendency to predict 1000 to 500-mb thicknesses too low over surface cyclones.
- The AVN can be too slow deepening cyclones, especially during the first 12 hours.
- The AVN often weakens southern stream systems or phases the two separate systems.
- The AVN is too slow with arctic airmasses plunging southward down the Plains.
- The AVN tends to overforecast upslope precipitation over the central/southern Rockies and strength of upslope flow.

- With strong wrapped up systems, the AVN forecasts the heavy precipitation too far north and west.
- The AVN lacks detail in the West compared to the ETA, although it is better than the NGM.
- The AVN tends to overdeepen weak tropical waves.
- During hurricane season, the AVN tends to be too strong with the subtropical ridge extending it too far to the west over the western Atlantic. This causes the AVN to track tropical systems too far to the west and doesn't allow them to turn to a more northwestward track.

- The AVN significantly underpredicts monsoonal precipitation in the Southwest US.
- The AVN overpredicts the number and strength of anticyclones over the Great Basin during the cool season.
- The AVN underpredicts MCS activity across the Plains during the warm season.
- The AVN is too far north and too strong with systems coming out of the Rocky Mountains.

Medium-Range Forecast Model (MRF)

THE MRF IS BASED ON A 126-WAVE GLOBAL SPECTRAL MODEL AND HAS A GLOBAL GRID OF 384 X 190, ROUGHLY 105 KM (EQUIVALENT TO 1° X 1° LATITUDE/LONGITUDE). THERE ARE 28 UNEQUALLY SPACED VERTICAL LEVELS IN THIS MODEL--FOR A SURFACE PRESSURE OF 1000 MB, 8 LEVELS ARE BELOW 800 MB, AND 7 LEVELS ARE ABOVE 100 MB.. THIS MODEL SERVICES THE AVN AND THE MEDIUM-RANGE FORECAST (MRF) RUNS AT NCEP. THERE ARE A VARIETY OF PRODUCTS PRODUCED BY THE MRF RUN, INCLUDING 7-DAY FORECAST TEMPERATURE ALPHANUMERIC BULLETINS AND SURFACE AND 500 MB PROGS OUT TO 15 DAYS. THE MRF IS RUN ONCE A DAY WITH A 00Z DATABASE, GENERALLY AVAILABLE BY 18Z.

Strengths

- The MRF is good at maintaining amplitude of waves. It is quite accurate at forecasting the long-wave pattern, even out to 10 days.
- MRF thickness progs are good for tracking polar outbreaks.
- Probably the major strength of the model is that it is the only available US model that forecasts past 72 hours.

Weaknesses

- The model is not as good as the NGM or ETA in defining smaller-scale systems. This leads to surface lows being forecasted too weak or not being forecasted at all.
- The 500 mb heights tend to be forecast too high in the high latitudes and too low in the low latitudes.
- The MRF has a cold bias, especially in the long-range progs.
- The MRF has a tendency to forecast too much upper air troughing over the northeastern United States.
- The moisture forecasts are usually too dry and have not performed well in the tropics.
- During hurricane season, the MRF, like the AVN, tends to be too strong with the subtropical ridge extending it too far to the west over the western Atlantic. This causes the MRF to track tropical systems too far to the west and doesn't allow them to turn to a more northwestward track.

Mesoscale Model Version 5 (MM5)

The Mesoscale Model Version 5 (MM5) is the Air Force's newest fine-scale meteorological model. At AFWA, MM5 was declared operational in late October 1997 and officially replaced the Relocatable Window Model (RWM) in mid-September 1998. Model resolutions vary, but the most common are outer nests of 45 or 54 km with inner nests of 15 or 18 km. **AFWA uses a 45 km outer nest and 15 km and 5 km inner nests.**

MM5 runs at finer resolutions than many of the models. Because of the increased resolution, output from MM5 will depict mesoscale features that may not be seen in either global scale models (AVN and NOGAPS) or larger scale regional models (NGM and RWM). Table 2-1 shows a comparison of the spatial and temporal resolutions of some CONUS regional models.

Regional Model	Grid Spacing(km)	Number of Vertical Levels
Mesoscale Model, Version 5 (MM5)	45, 15, and 5	41
ETA	32	45
Meso-ETA	29	54
Relocatable Window Model (RWM)	92.3	16
Nested Grid Model (NGM)	80	16

Table 2-1. Comparison of Forecast Regional Models

MM5 Strengths and Weaknesses

Due to the choices available for MM5 configurations, it is difficult to make "blanket" statements about MM5’s ability to forecast various parameters, e.g., the speed of fronts, the development of lee cyclogenesis, the intensity of convection, the amount of precipitation, or the accuracy of the forecast low temperatures**. Currently at AFWA, MM5 is initialized from the previous run of another larger-scale model, the AVN**. That means there are no observations that are directly analyzed for the AFWA MM5 initial state. The initial conditions for MM5 largely reflect the "goodness" of the 6-hour or 12-hour larger-scale model forecast from the previous cycle, with very little "correction" to the "current" state of the atmosphere. If the larger-scale model is handling the state of the atmosphere well, it will be reflected in the MM5 forecast, and vice-versa.

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At AFWA, objective and subjective verification of MM5 occurs on a daily basis. So far, there are indications that **cloud forecasts associated with weather systems and convection tend to be good. Forecasts of low stratus and stratocumulus have verified nicely, while forecasts of fair weather clouds are generally not as good**. Other areas of strength have been the temperature forecasts, the winds, and sea-level pressure verification. Along with general model characteristics, specific strengths and weaknesses have been identified with each AFWA MM5 window.

Information flow MM5